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Building AMERICA
U.S. Department of Energy
Research Toward Zero Energy Homes

John Straube, Ph.D., P.Eng
Roofs
Roofs, Attics, and Cathedrals
Building Science Corp

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University of Waterloo

Pitched and Ventilated Attic Roof

Typical Construction Materials

1 Wood framed rafter and joist (shown) or wood truss Steel framed rafter and joist or truss	5 Asphalt impregnated felt Asphalt impregnated building paper Permeable polymer "housewrap" Impermeable self-sealing membrane
2 Cedar shakes (shown) Metal panels, standing seam Asphalt Shingles Exposed Membranes	6 Drywall (shown) Spray-foam on substrate membrane (supported)
3 Batt (shown) Blow-in cellulose fiberglass, rockwool Spray Foam	8 Painted drywall (shown) Wood paneling Vinyl wallpaper on drywall Textured coating
4 Optional Paint or vinyl wallpaper on drywall Polystyrene Ins-backed drywall Kniff facing on batt	

Conceptual Drawing only! Important details not shown, just arrangement of layers. Some combinations may not be practical or may perform poorly.

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Example of Pitched and Ventilated Cathedral Ceiling Roof

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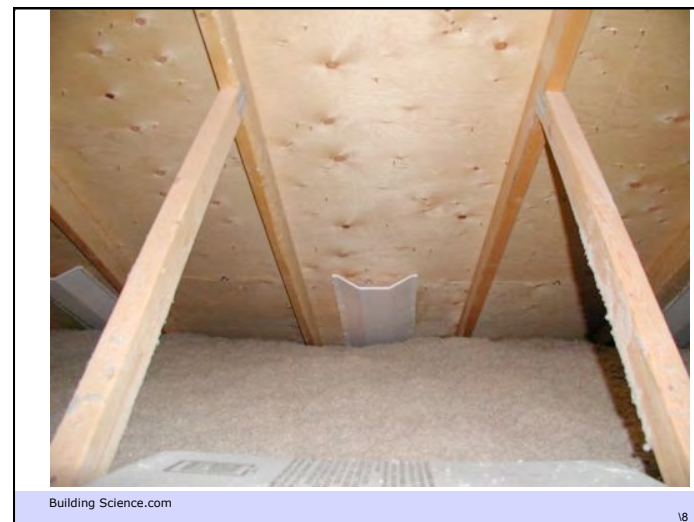
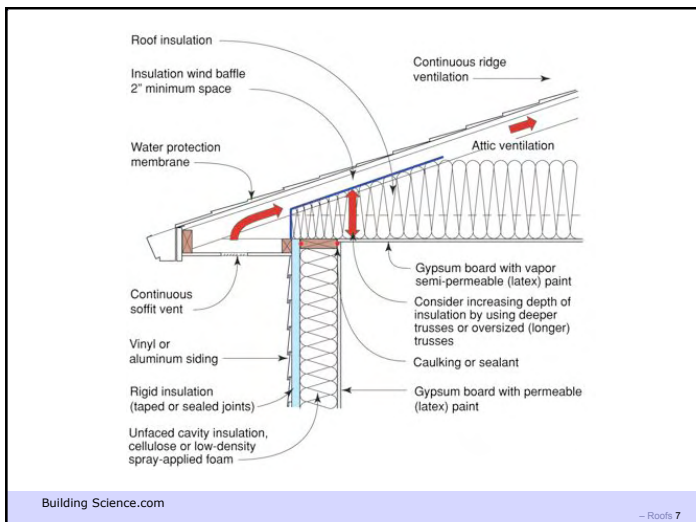
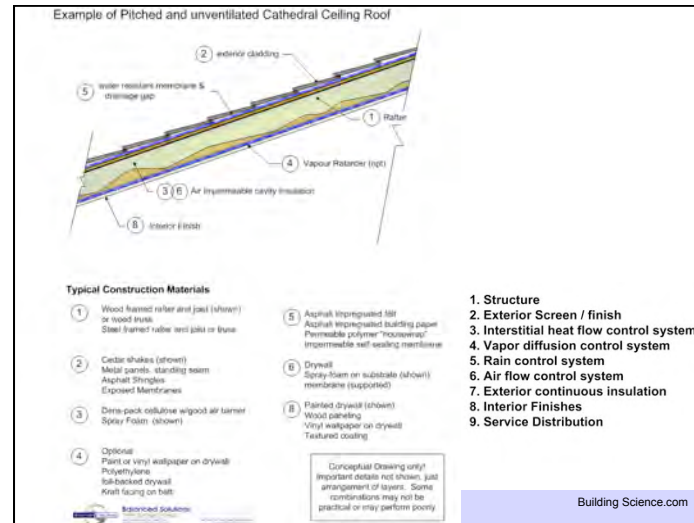
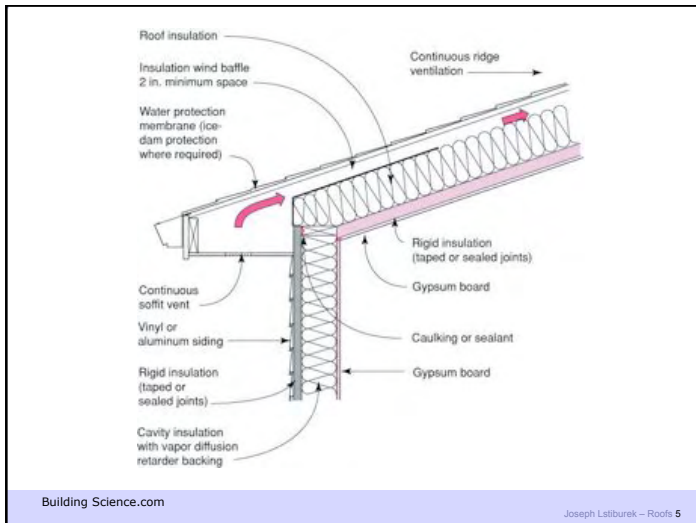
Example of Pitched and unventilated Cathedral Ceiling Roof

Typical Construction Materials

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2 Cedar shakes (shown) Metal panels, standing seam Asphalt Shingles Exposed Membranes	6 Drywall (shown) Spray-foam on substrate (shown) membrane (supported)
3 Dens-pack cellulose fiberglass, wood batten Spray Foam (shown)	7 Expanded Polystyrene Extruded Polystyrene Wood Firm Board Products
4 Optional Paint or vinyl wallpaper on drywall Polystyrene Ins-backed drywall Kniff facing on batt	8 Painted drywall (shown) Wood paneling Vinyl wallpaper on drywall Textured coating

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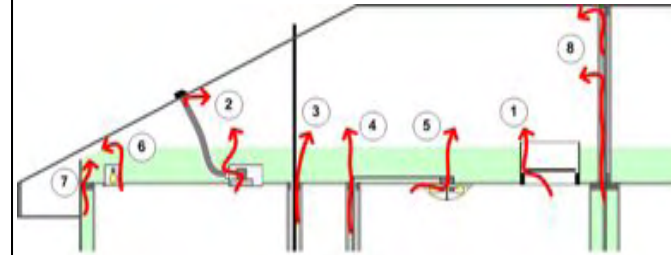
Vented Attics

- Air leakage thru ceiling is a problem in colder climates
 - Ducts are a disaster
- Condensation and heat gain on ducts in warm climates
- Modern roofs often hard to vent

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How do I leak?

- Let me count the ways ...



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Big Air Leakage Points

- Ductwork
- Partitions
- Dropped soffits
- Cabinetry
- Ceiling lights
- Rimjoists
- Plumbing stacks
- Attic hatch

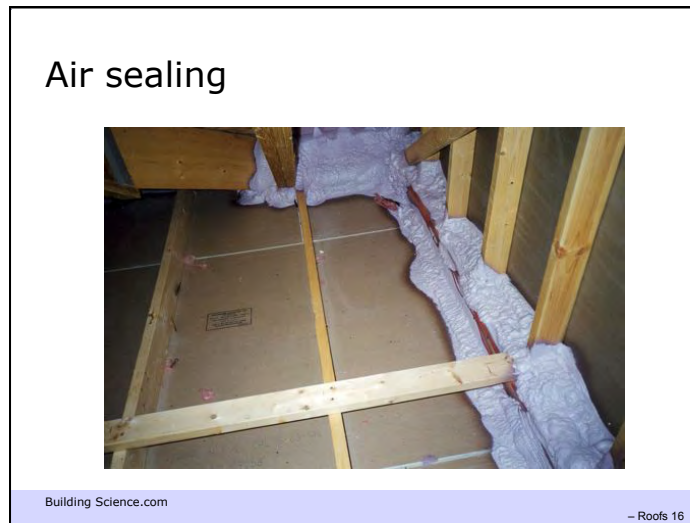
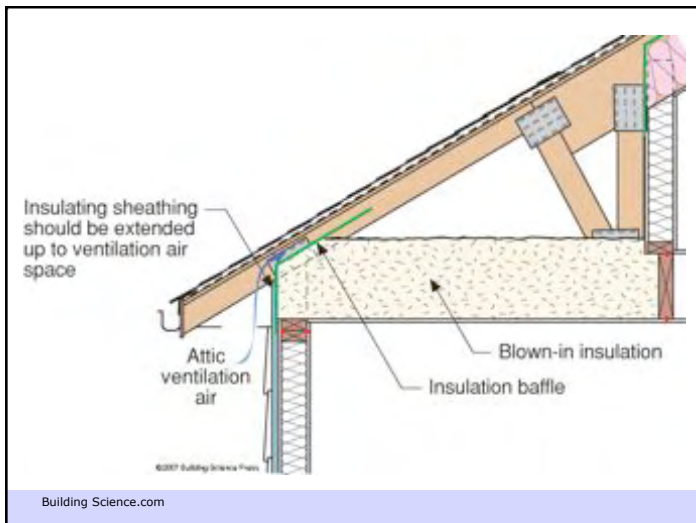
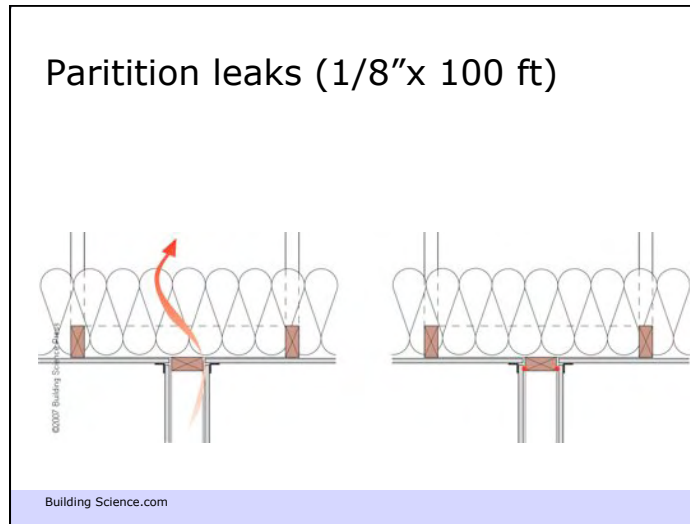
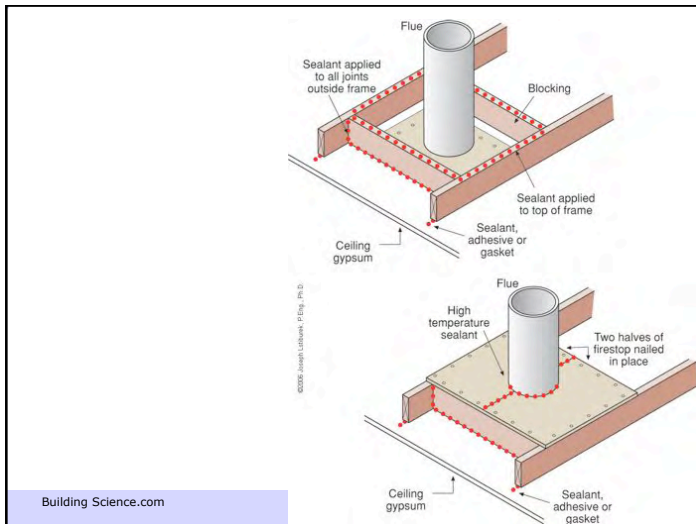
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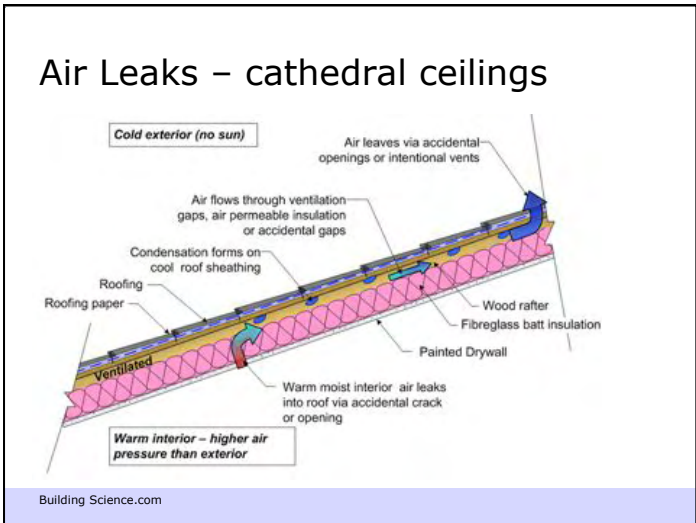
Airflow Control No. 11/79

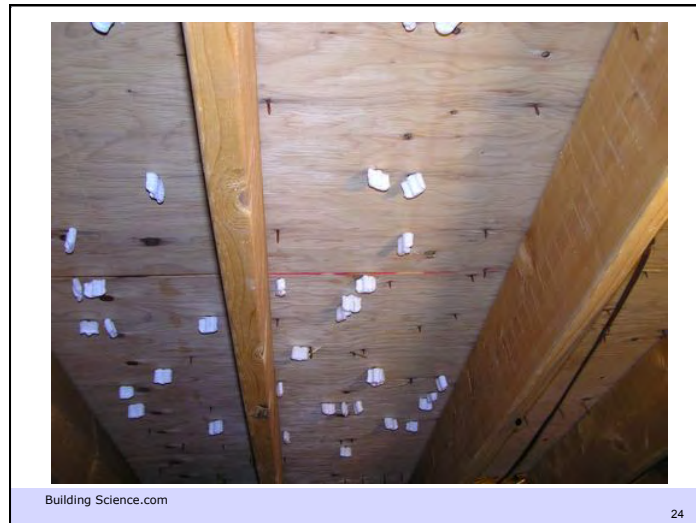
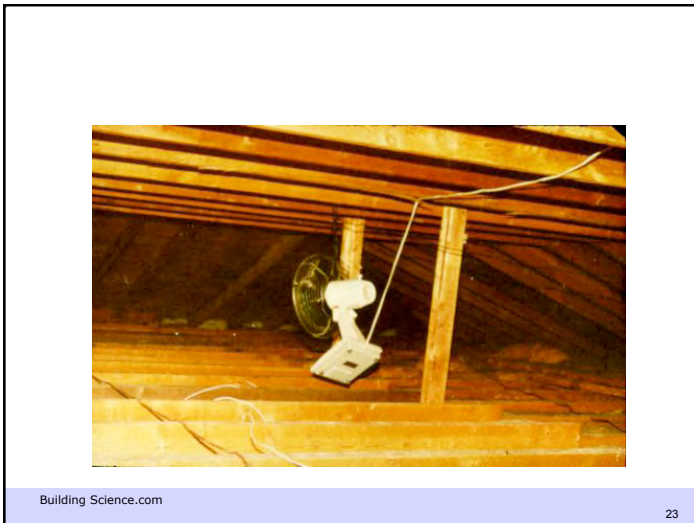
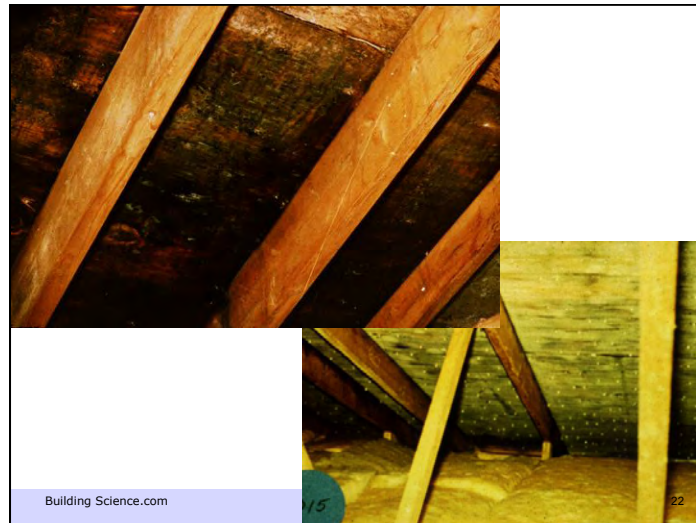
Avoid placing recessed lights in insulated ceilings unless they are specifically designed to be airtight. Install IC-rated fixtures that have passed the ASTM E-283 test for air leakage.

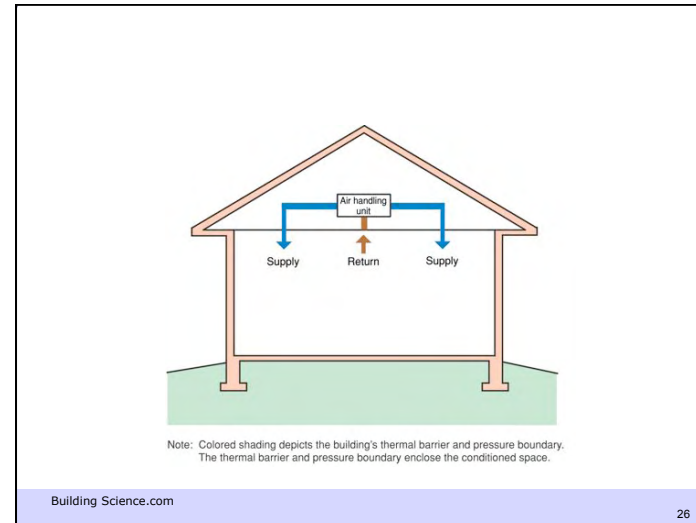
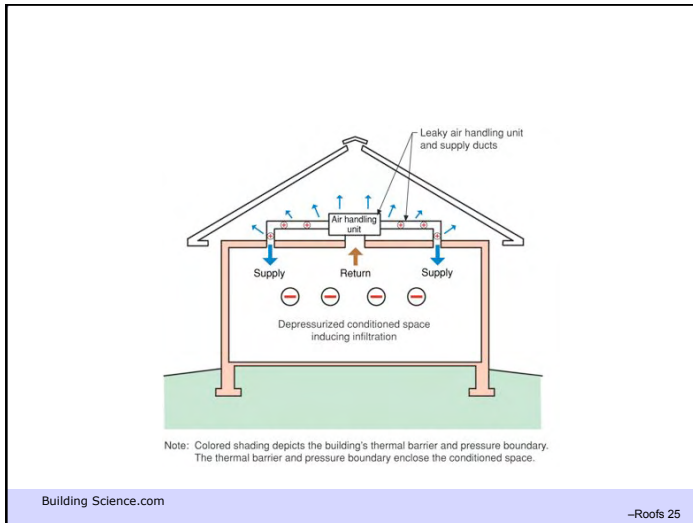
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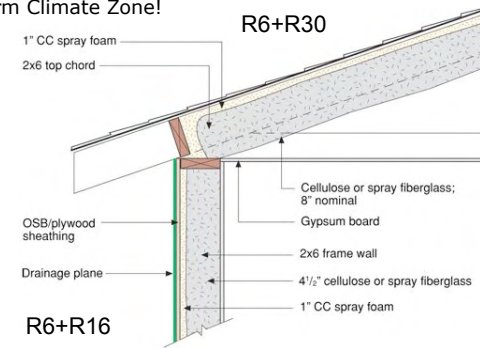
Unvented Cathedral Ceilings

- Not absolutely necessary to vent if airtight and vapour tight material,
 - e.g. spray foam.
 - Or insulated sheathing
- May be most practical in retrofit
- If no wetting, little drying required
 - Demands very high performance
 - >R40, no penetrations
 - spray foam is a practical solution
 - beware thermal bridges

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Hybrid: Air, thermal, fire

Warm Climate Zone!

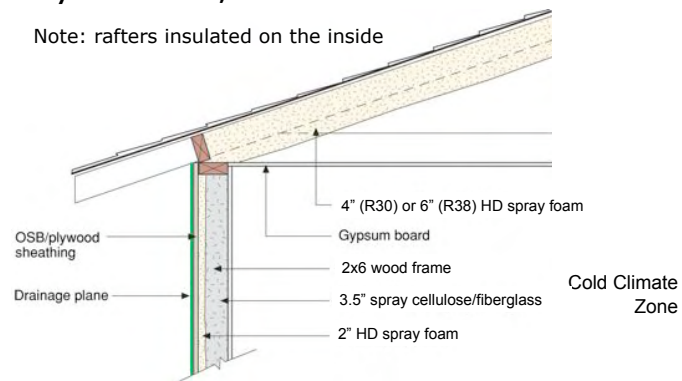


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Insulation and Thermal Bridges No. 30/65

Hybrid: Air, thermal

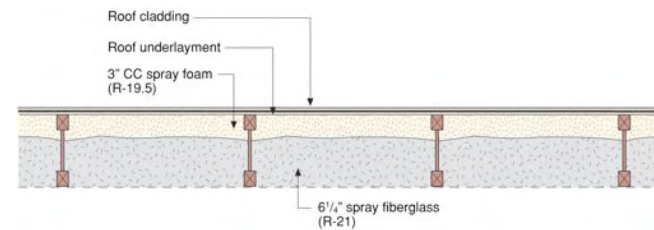
Note: rafters insulated on the inside



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Insulation and Thermal Bridges No. 31/65

R40+ roof, fire protection

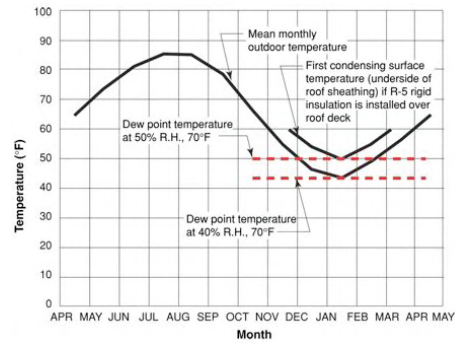


Cold Climate (Zone 5/6) Solution

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Insulation and Thermal Bridges No. 32/65

Calculation



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Hybrid Roofs with code levels of insulation

- IRC 2007 Supplement

TABLE R806.4
INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM RIGID BOARD OR AIR-IMPERMEABLE INSULATION R-VALUE ^A
2B and 3B tile roof only	0 (none required)
1, 2A, 2B, 3A, 3B, 3C	R-5
4C	R-10
4A, 4B	R-15
5	R-20
6	R-25
7	R-30
8	R-35

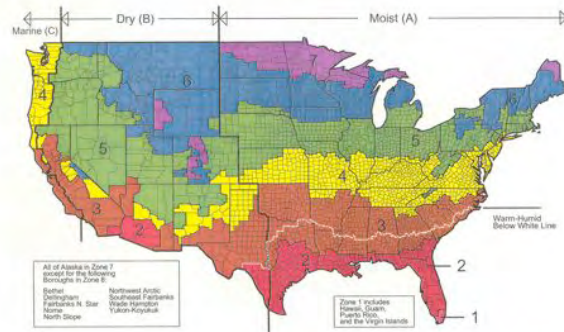
a. Contributes to but does not supersede Chapter 11 energy requirements.

... or air impermeable insulation

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Map of DOE's Proposed Climate Zones

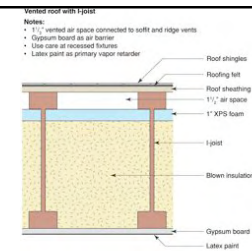


March 24, 2003

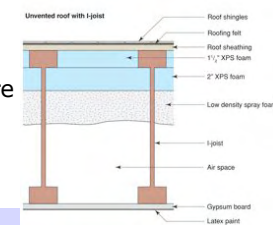
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Simple Vented roof
Air leaks!
Ventilation path?

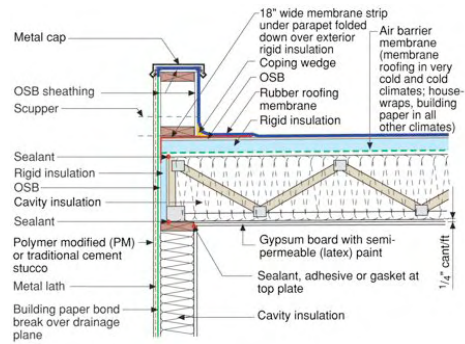


Unvented roof for more complex roof lines



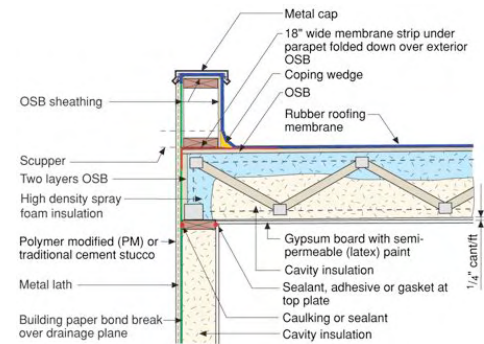
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Low Slope Roofs



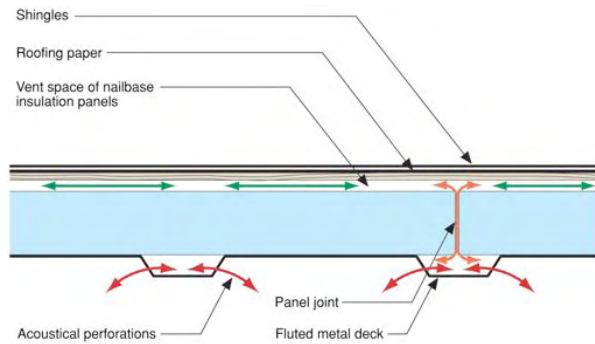
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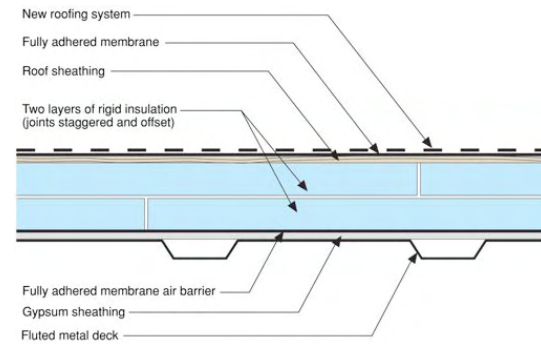
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Low Slope Commercial



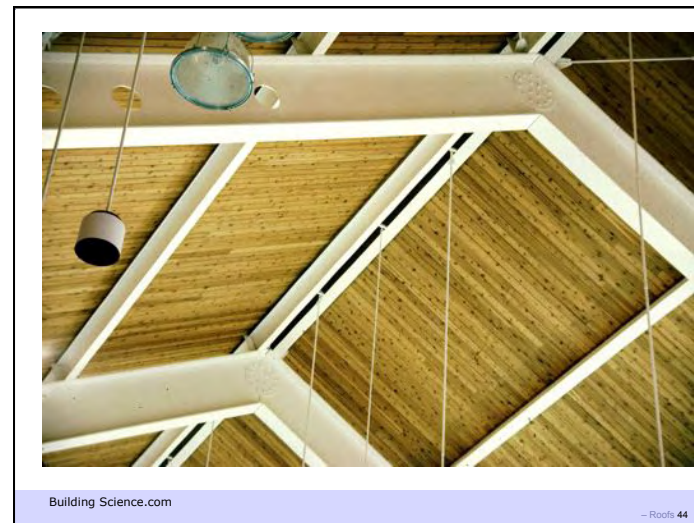
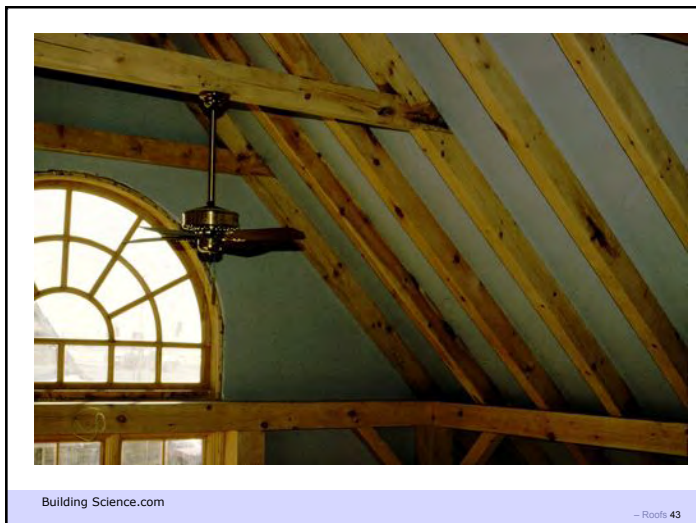
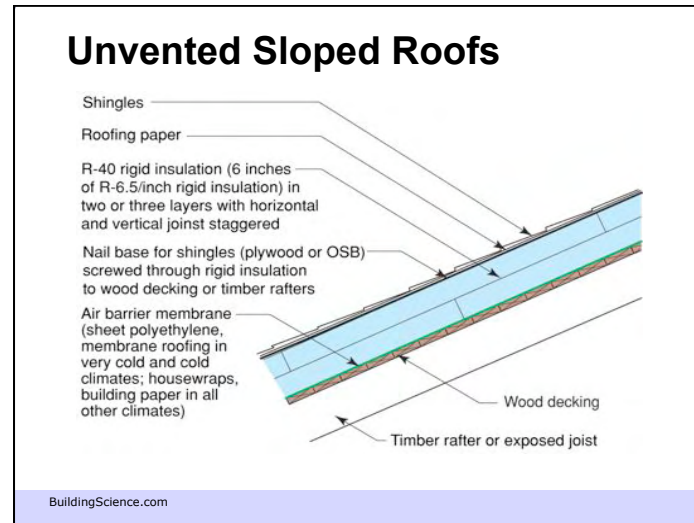
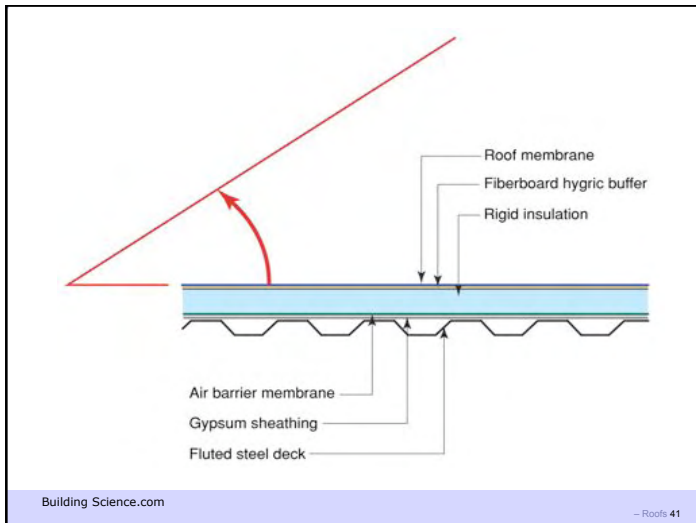
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Best Practise Exposed Membrane



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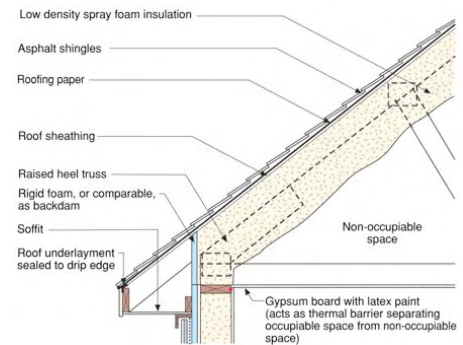
Roofs 46



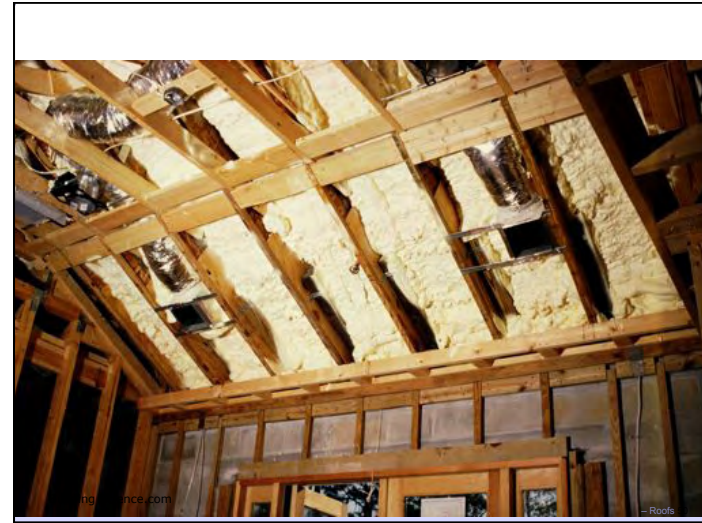
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Roofs 47

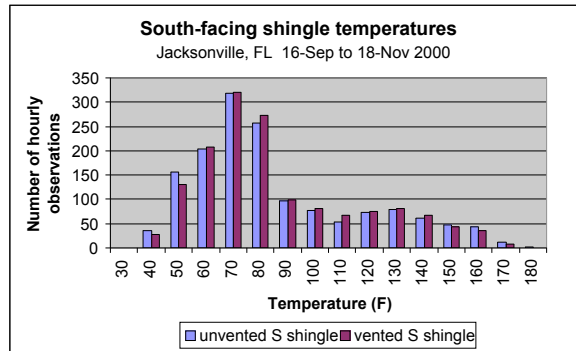
Zone 4 or lower



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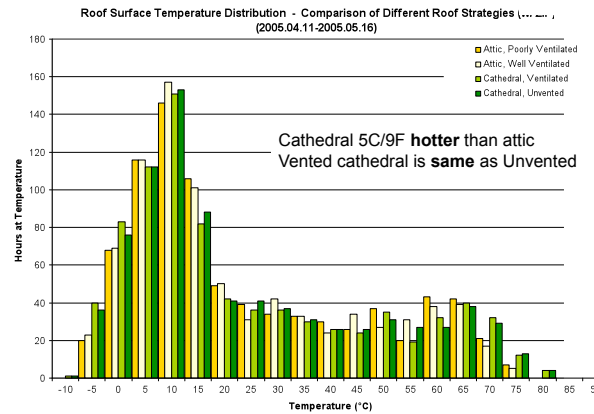
Vented vs. unvented shingle temperatures



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Ventilation & Roof Temperature



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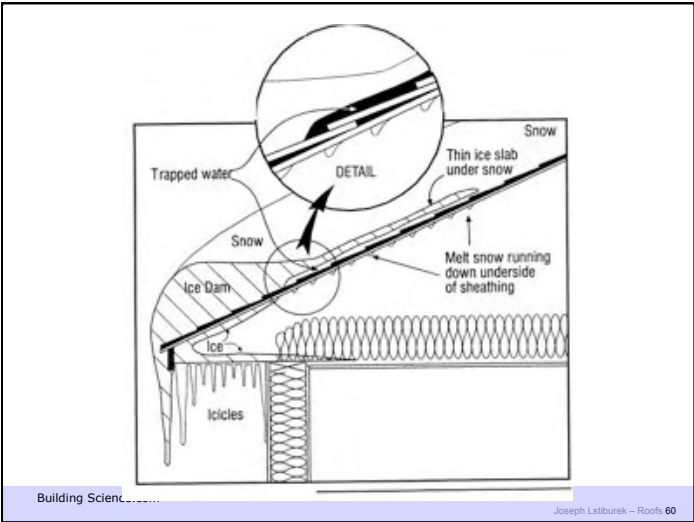
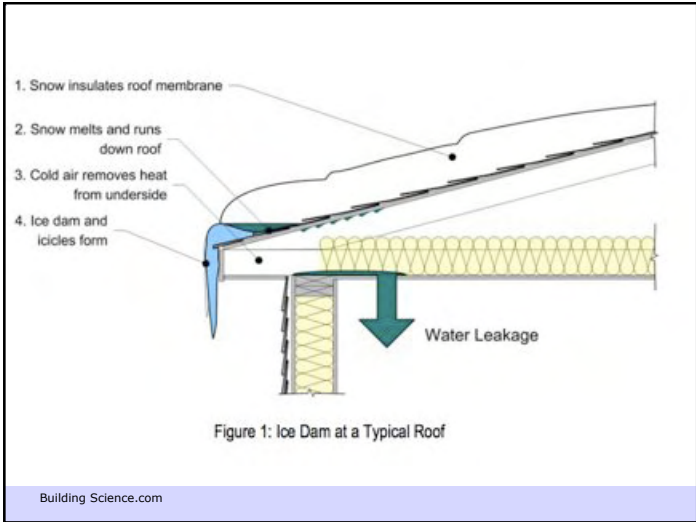
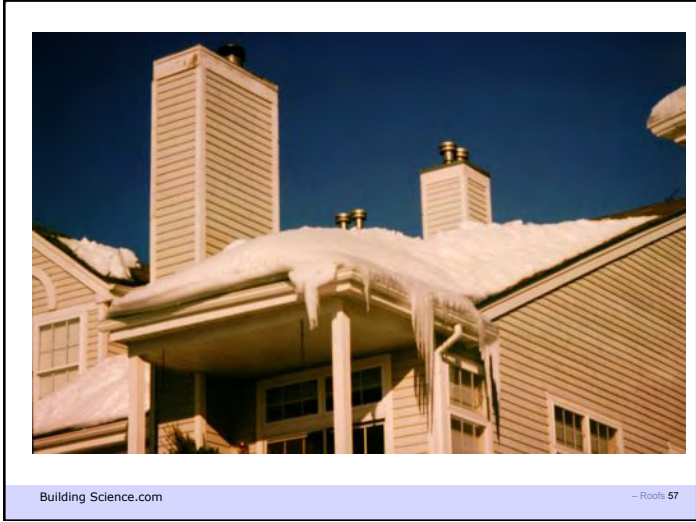
Roof ventilation could provide cooling

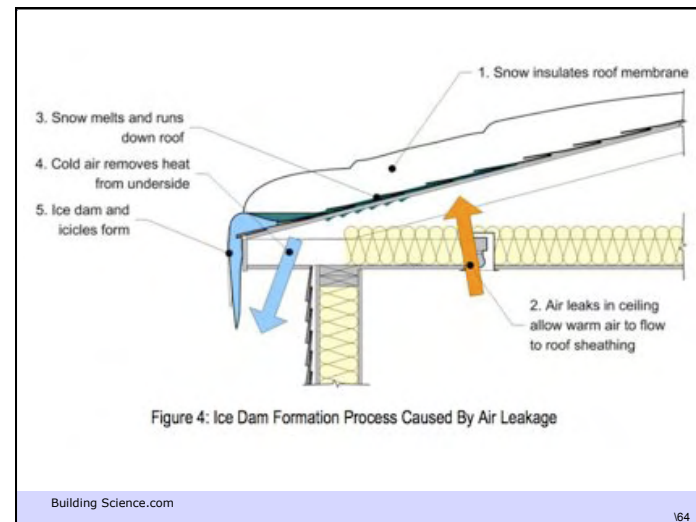
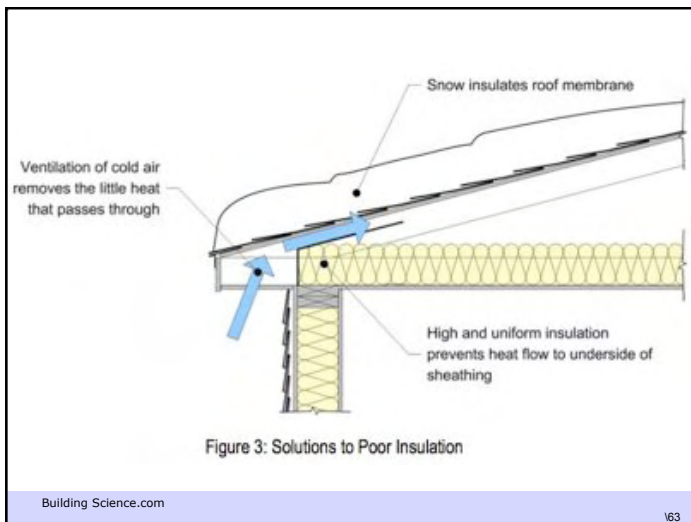
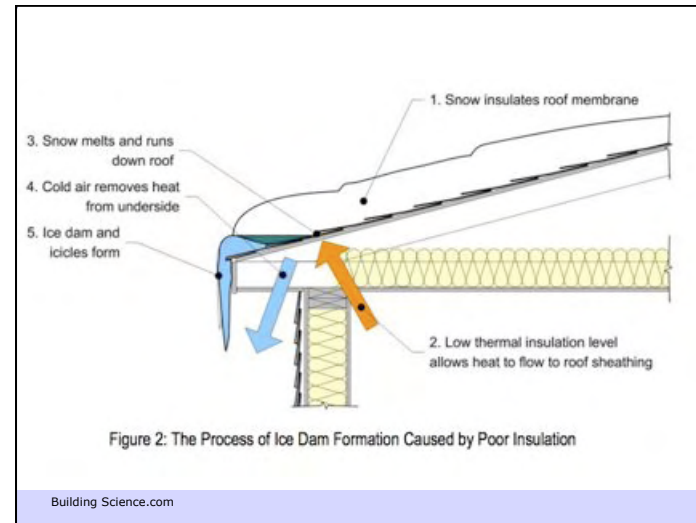
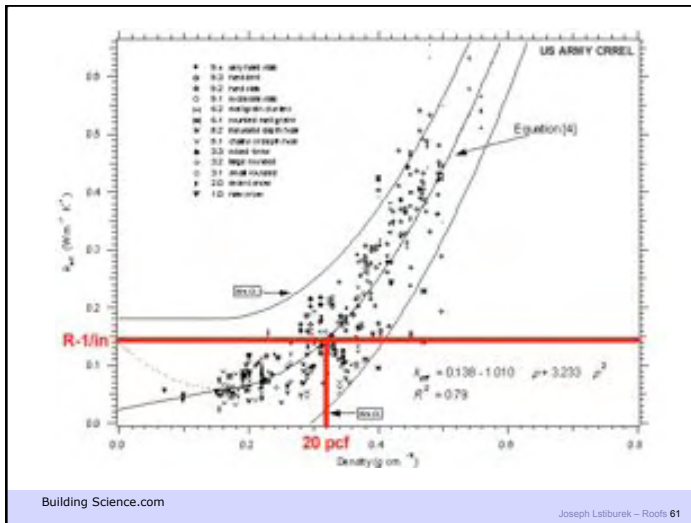


Ice Dams

- Cold Climate problem
- Need snow and temperatures around freezing

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Conclusions

- Highly ventilated open attic is with R60+ of low cost fibrous insulation is best
 - Requires exceptional air sealing of ceiling
 - No duct work!
- Unvented roofs provide more options
 - Airtightness is critical to success
 - Requires spray foam or full adhered membrane

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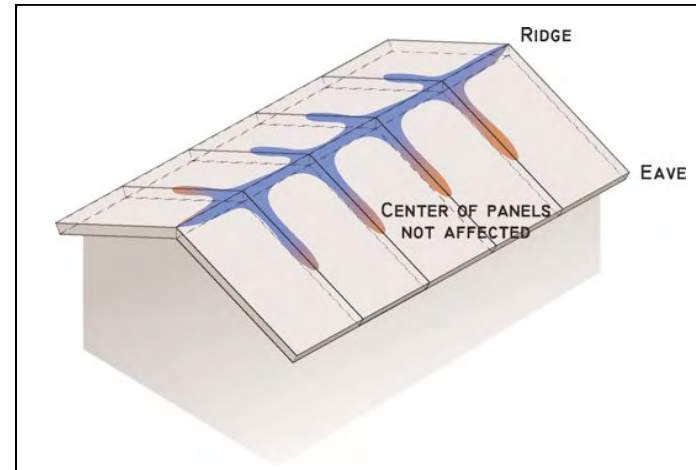
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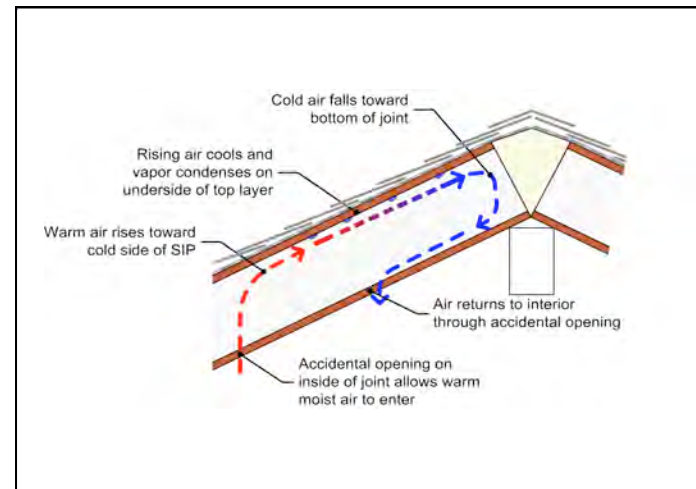
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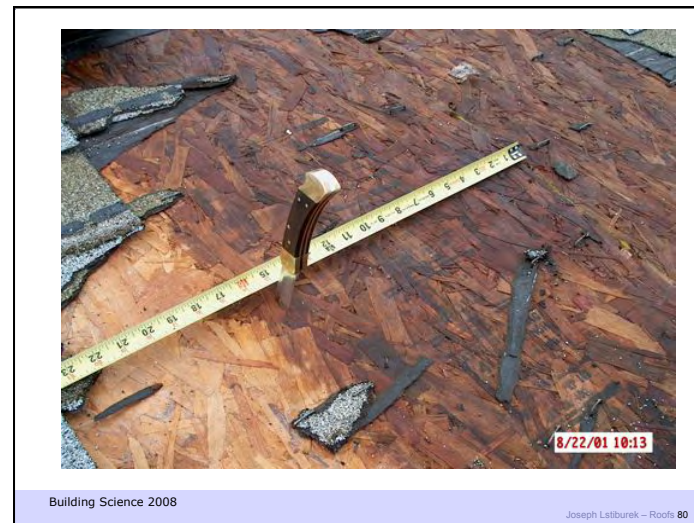
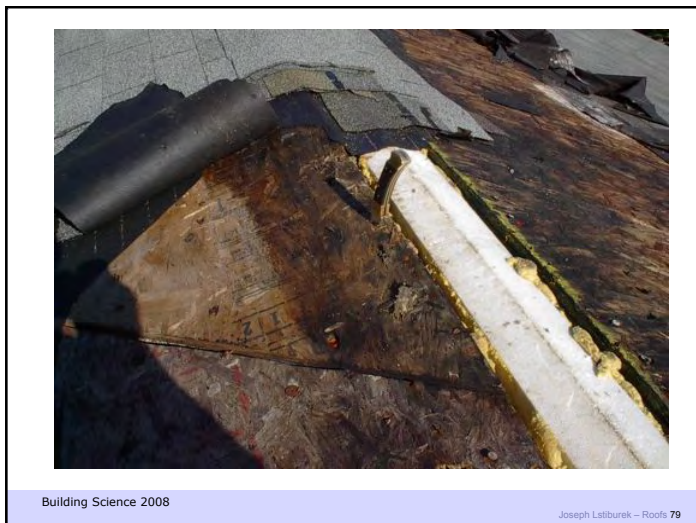
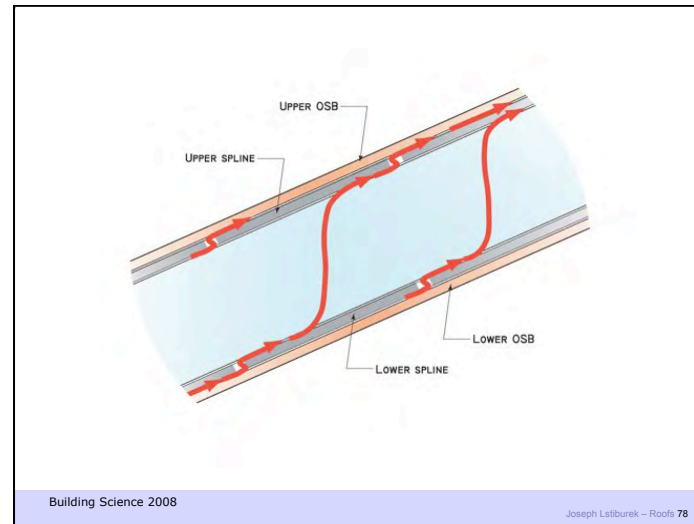
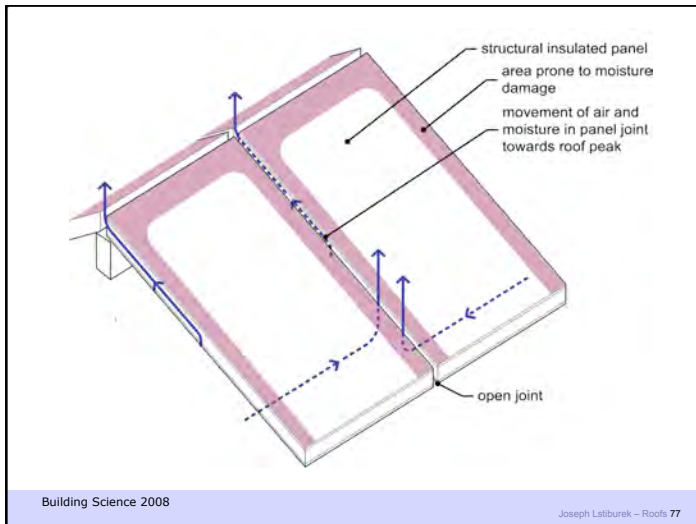
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